Learning Jazz Grammars

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Jazz Learning Approaches

- **Traditional**:

  Transcribe, and learn to imitate,
  solos of great masters.

- **Impro-Visor**:

  Write your **own** solos, understanding
  the chord changes in the process.

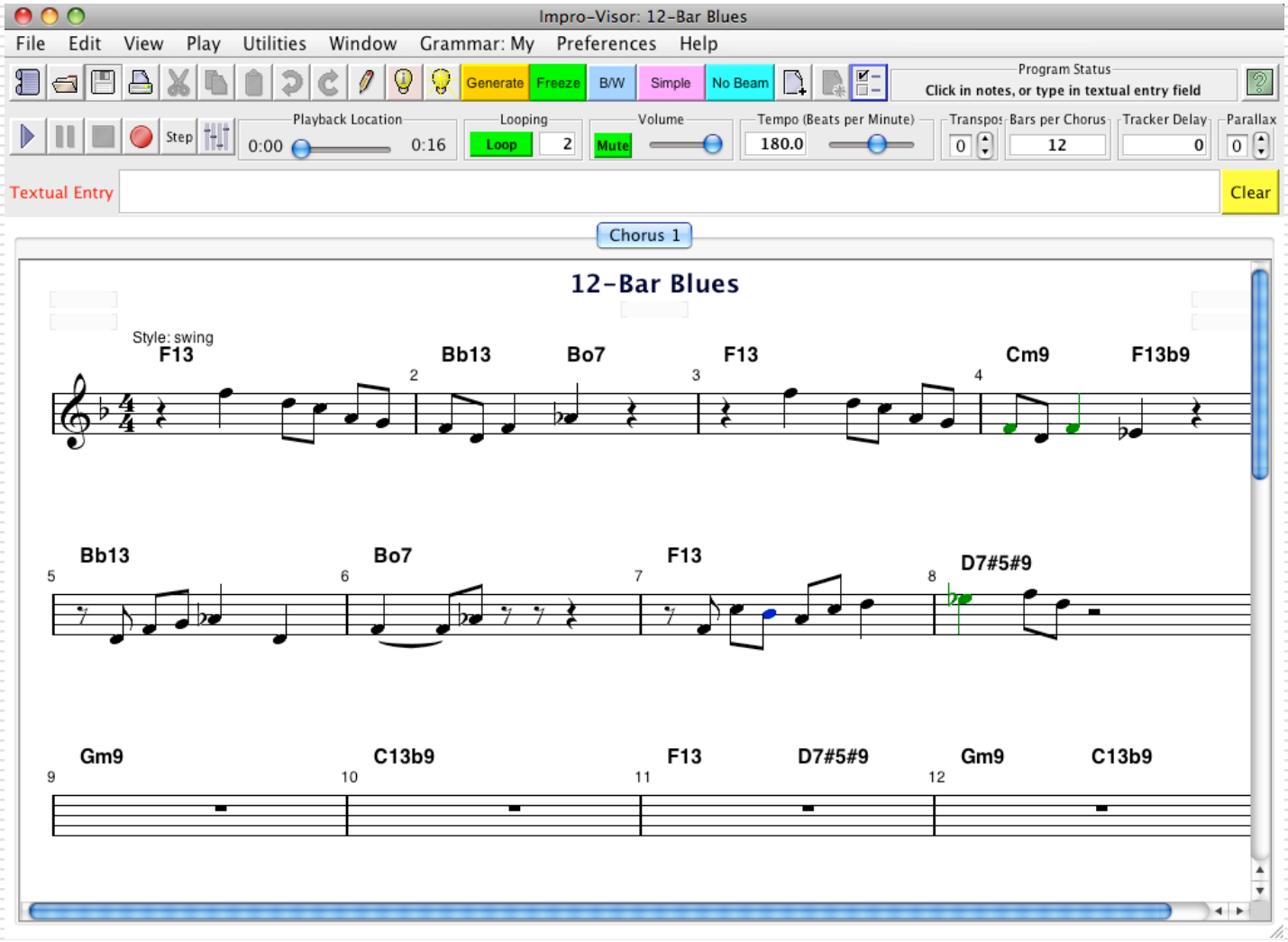
  Use part or none of what you wrote, as you please,
  in actual improvisation.

Background: Impro-Visor

- **Impro**visation + Ad**visor**
- Educational software to help musicians:

  teach themselves to improvise jazz over chord changes
- "Advice" includes suggestions for jazz licks:
  - From a user-modifiable database, **or**
  - From a "lick generator".

Impro-Visor v.4 Lead-sheet Screen Shot



Constructing a Lick Database

- Educational in its own right
- Laborious and time-consuming
- Difficult to achieve coverage of every situation (e.g. every possible pair of consecutive chords)
- That motivated the Lick Generator.

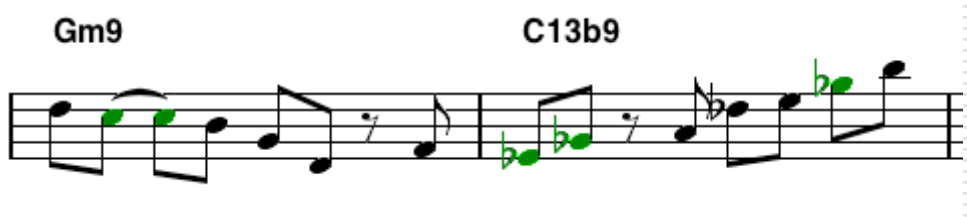
Lick Generator

Chord Sequence In

Gm9 | C13b9

Generate

Lick Out



Lick Generator (SMC 2007, Lefkada)

- Built on a **probabilistic context-free grammar**.

  V2 → X2 (prob 0.2)
  V2 → X8 X4 X8 (prob 0.8)
  V4 → X4 (prob 1)

- Some rules add arguments to control **filling beats**

  P(Y) → V2 P(Y-2) (prob 0.5)
  P(Y) → V4 V4 P(Y-2) (prob 0.5)
  P(0) → () (prob 1)

  P(N) is the **start symbol** if there are N beats to fill

- **User-modifiable**
  (by a sophisticated user)

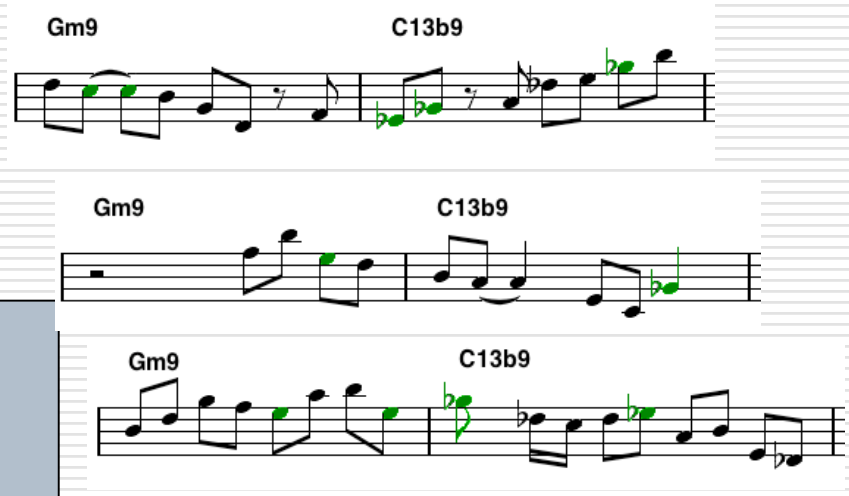
Constructing a Grammar

Difficulties Analogous to Constructing a Database

- Also educational in its own right
- Trial-and-error to get exactly the right style
- Motivates Grammar Learning

Grammar Generator

Performances
Transcriptions In



Learn

Grammar Out

…
(rule (V2) (S8 S8 S8 S8) 0.3)
(rule (V4) (H8/3 H8/3 A8/3) 0.01)
(rule (V4) (H8/3 H8/3 H8/3) 0.05)
(rule (V4) (H8/3 S8/3 H8/3) 0.02)
(rule (V4) (N4) 0.22)
(rule (V4) (V8 V8) 0.72)
(rule (V8) (H16 A16) 0.01)

Vision

- Grammar generator would help construct a **repertoire** of selectable grammars
  - Different performance styles
  - Varying difficulties
  - Lick-trading patterns

Grammar Learning Problem

- Create, from a corpus of transcribed performances, a grammar that captures the stylistic elements represented in the corpus.

- How do we capture the style?
  - Note categories form abstract melodies
  - Contours, slopes give more micro-structure
  - Clustering reduces complexity
  - Markov chains give macro-structure

Note Categories

Over a given chord, each note in the chromatic scale has a pre-specified category, one of:

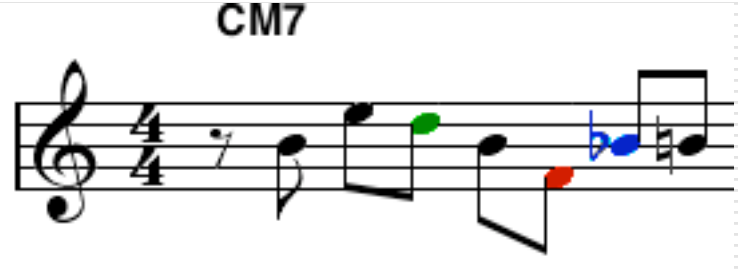
- Chord tone
- Color tone (not in chord, but sonorous with it)
- Approach tone (frequently used in jazz)
- Other (“outside”, in jazz parlance)

Color-Coding Note Categories

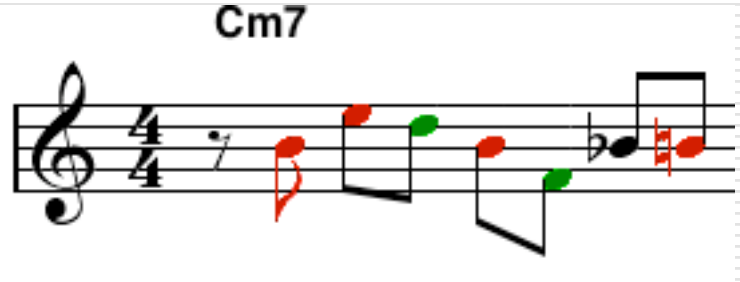
- Chord tone: Black
- Color tone: Green
- Approach tone: Blue
- Other: Red

Coloration Examples

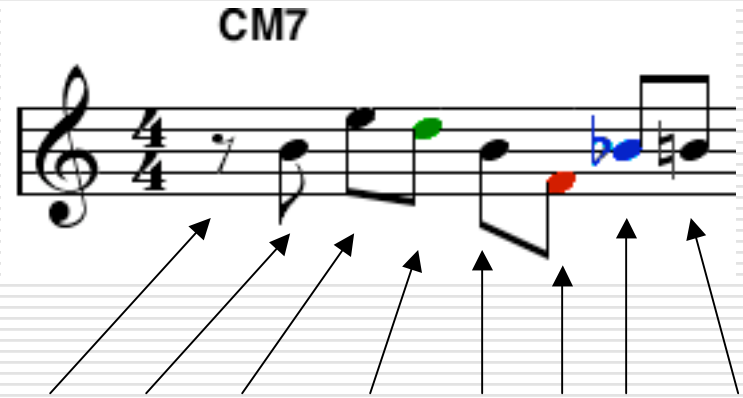
C Major 7th chord



C minor 7th chord



Textual Representation of Melody

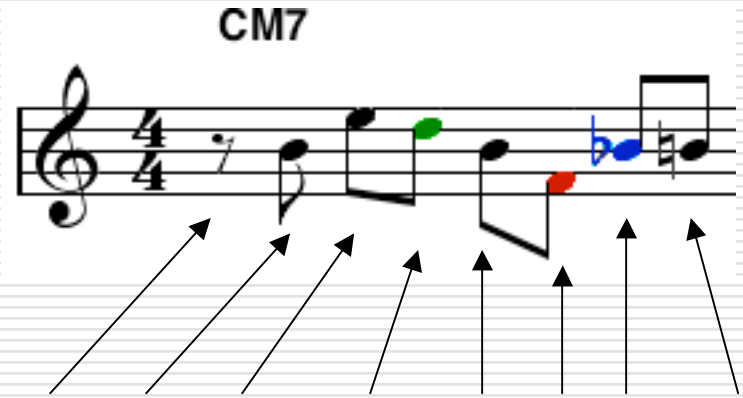


Concrete melody: r8 b8 e+8 d+8 b8 f8 bb8 b8

Textual Representation of Note Categories

- Chord tone: Black C
- Color tone: Green L
- Approach tone: Blue A
- Other: Red
  - Scale: S
  - Arbitrary: X
- Abbreviation: H = C or L
- R = rest

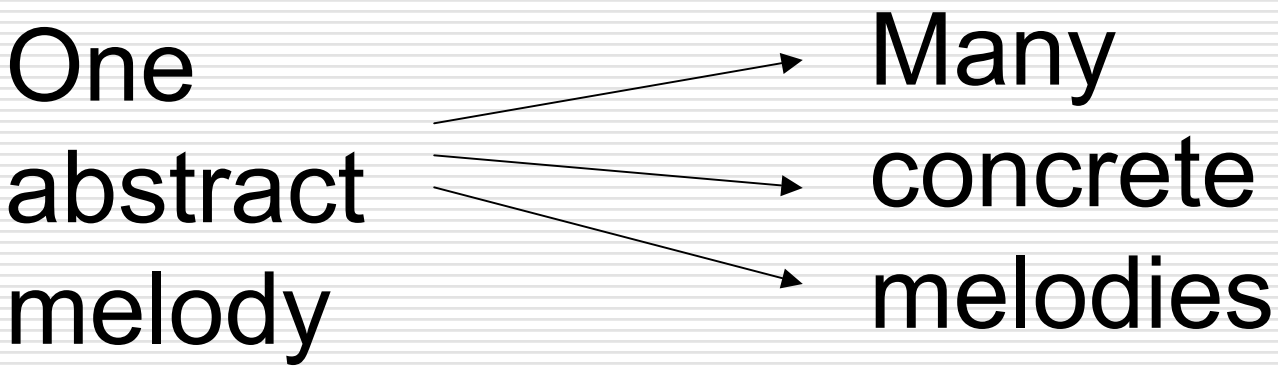
Textual Representation of Abstract Melody



Concrete melody: r8 b8 e+8 d+8 b8 f8 bb8 b8

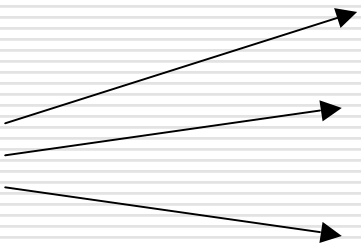
Abstract melody: R8 L8 C8 L8 C8 S8 A8 C8

Many-Many Relations



Many-Many Relations

One concrete melody



Many abstract melodies

But this direction can be turned into a **function** using a few procedural rules.

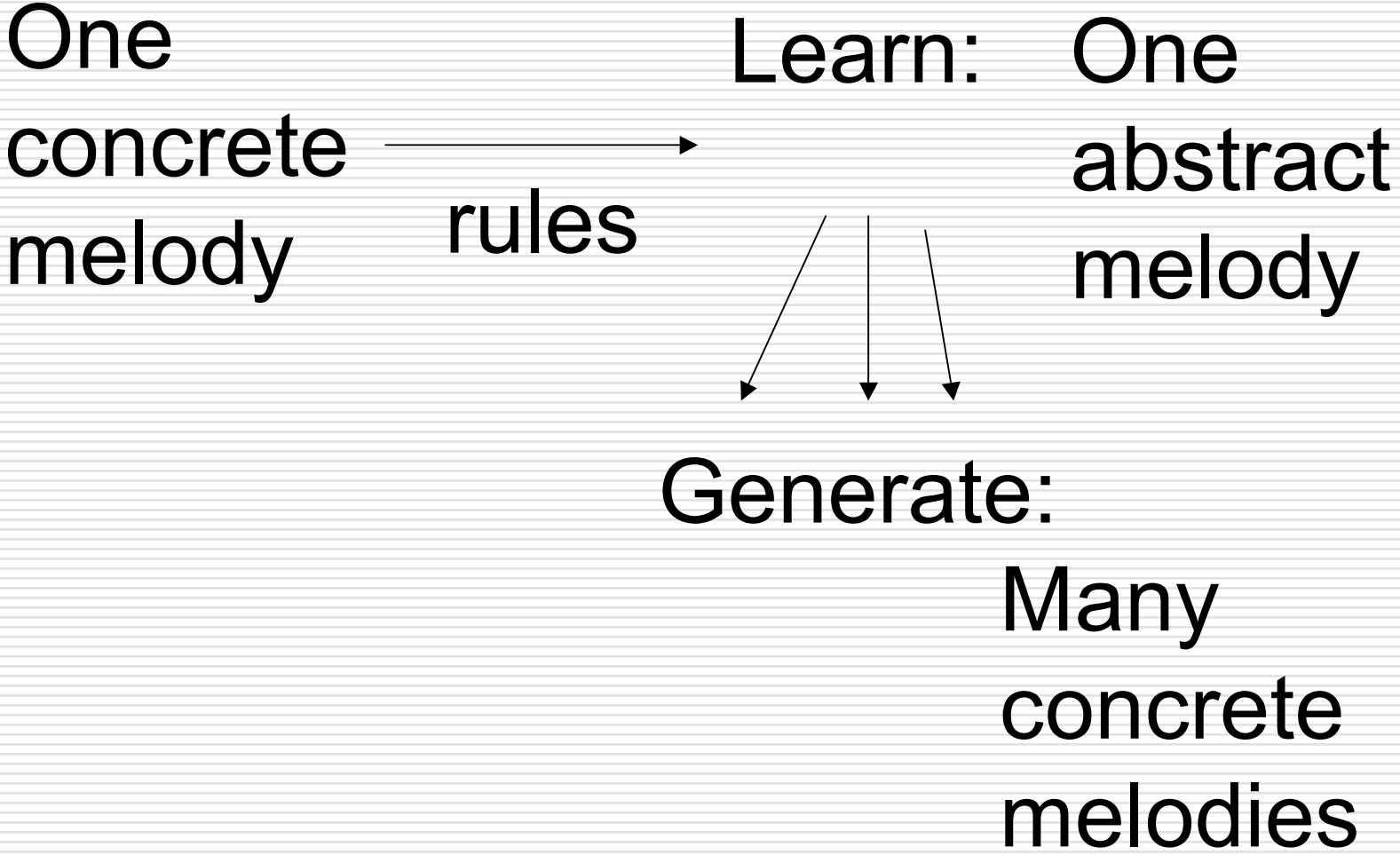
Many-Many Relations

One concrete melody

rules

One abstract melody

Our Generation Principle



First Challenge

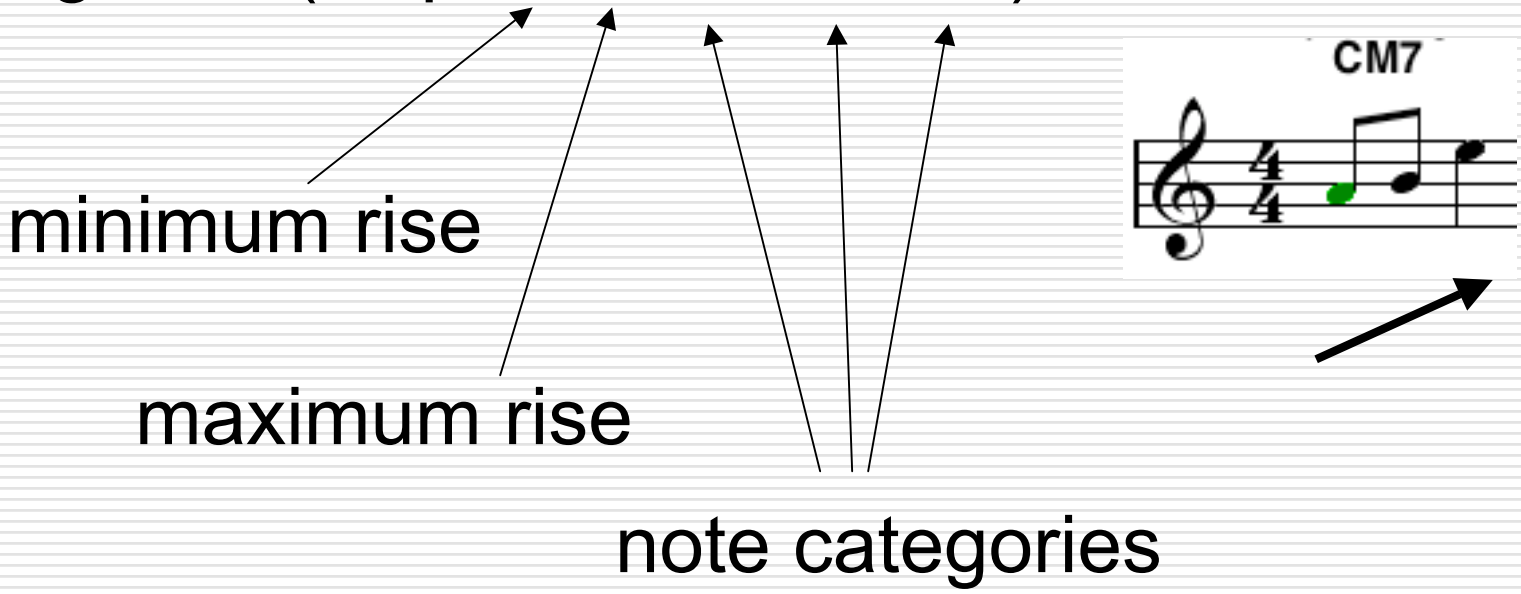
- Abstract melodies, as permitted so far, are too liberal in their generation.

- They cannot capture melodic **contour**.

Solution to First Challenge

- Add new units to represent slope & contour

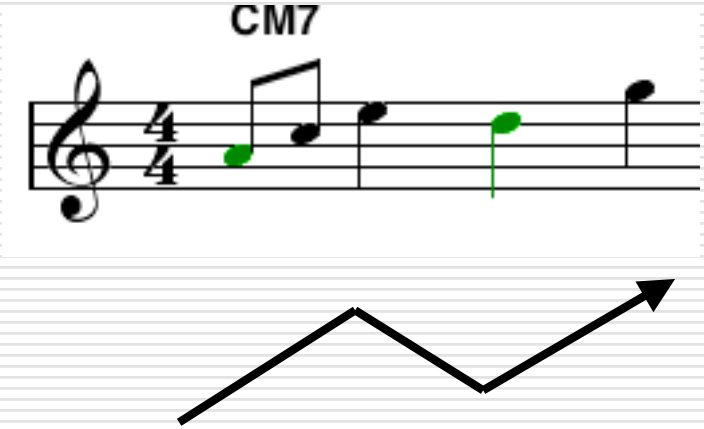
- e.g. unit (slope 1 5 S8 S8 C4)



Solution to First Challenge, cont'd

- Chained slopes = **Contours**

(slope 1 5 S8 S8 C4)(slope -2 -4 L4)(slope 5 5 C4)



[Some touching up may be done if the constraints of the contour can't be met exactly.]

Second Challenge

- Retaining too many abstract melodies in the grammar is apt to slow things down.

Solution to the Second Challenge

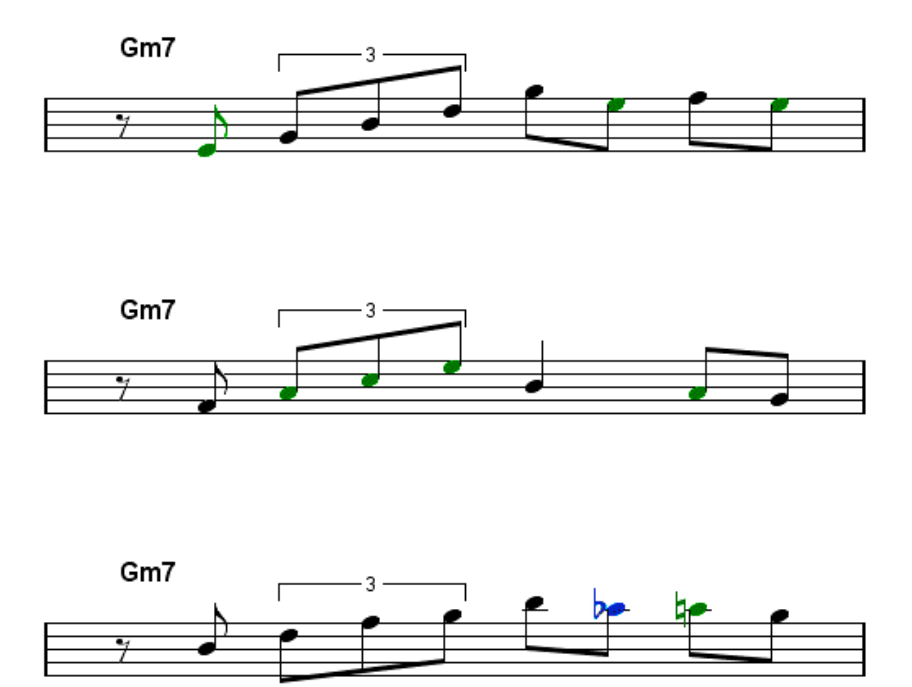
- **Cluster** the abstract melodies and select a few representatives of each cluster.
- This entails creating a distance metric between abstract melodies, which we have done.
- So far, only k-means clustering has been used.

Parameters Used in Metric

- number of notes
- total duration of rests
- average maximum slope
- phrase starts on or off the beat
- order of the contour (number of direction changes)

Cluster Examples

Three representatives from the same cluster:



Third Challenge

- Concatenating abstract melodies arbitrarily does not provide for a convincing style emulation.

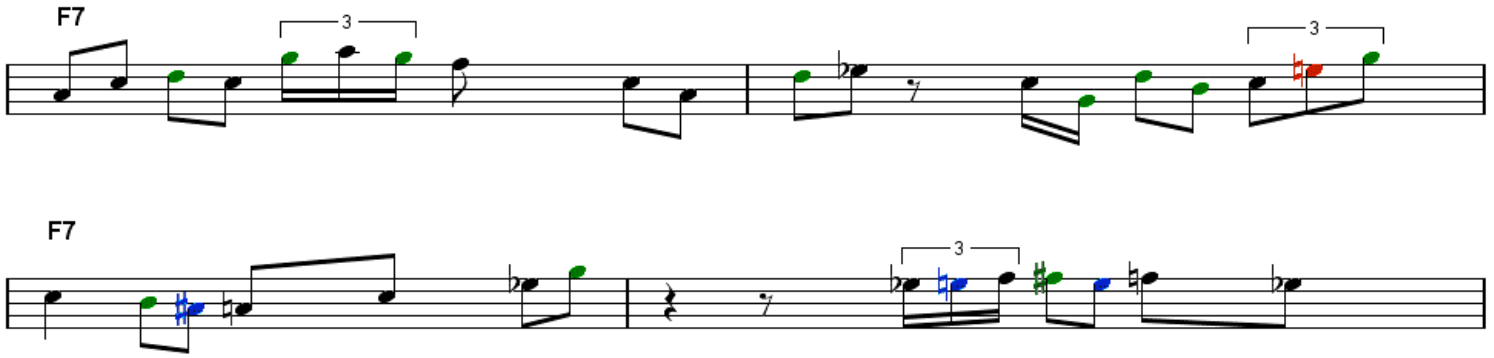
Solution to the Third Challenge

- Infer transition probabilities for **Markov chains** between clusters.
- States of Markov Chain are non-terminals in the grammar.
- Incorporate the probabilities into the grammar rules, which are already probabilistic.

Markov Imitation Example

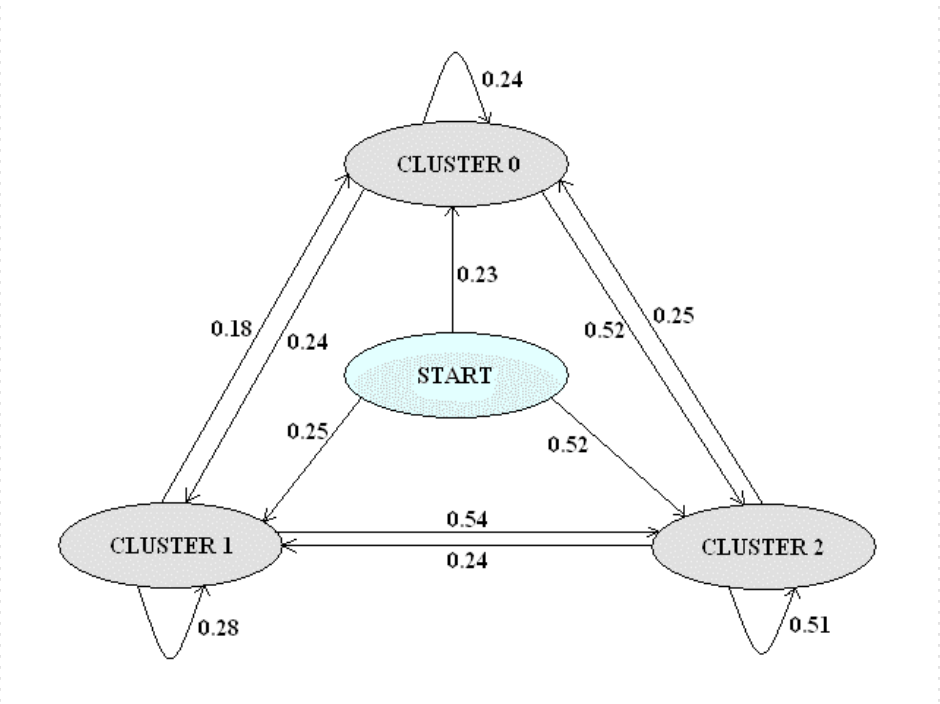
Original two-measure melody

and two measures of imitation with a Markov model:



Markov Models

Markov model diagram for grammar rules (next slide):

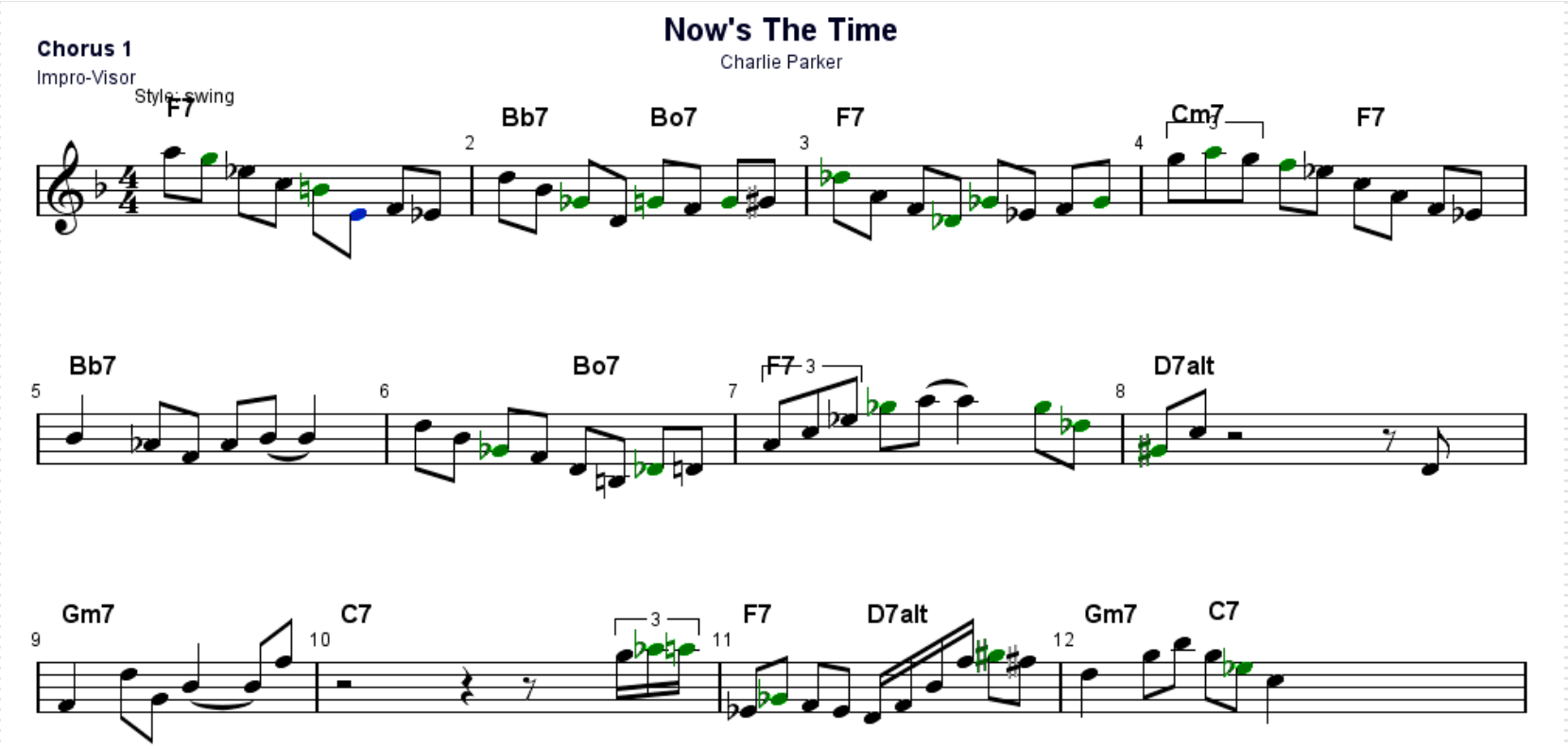


Example of Inferred Markov Grammar Rules

Inferred from a corpus of Charlie Parker solos:

- **(rule (START Z) ((Cluster0 Z)) 0.23)**
- **(rule (START Z) ((Cluster1 Z)) 0.25)**
- **(rule (START Z) ((Cluster2 Z)) 0.52)**
- **(base (Cluster0 0) () 1)**
- **(base (Cluster1 0) () 1)**
- **(base (Cluster2 0) () 1)**
- **(rule (Cluster0 Z) (Q0 (Cluster2 (- Z 1))) 52.00)**
- **(rule (Cluster0 Z) (Q0 (Cluster1 (- Z 1))) 24.00)**
- **(rule (Cluster0 Z) (Q0 (Cluster0 (- Z 1))) 24.00)**
- **(rule (Cluster1 Z) (Q1 (Cluster2 (- Z 1))) 54.04)**
- **(rule (Cluster1 Z) (Q1 (Cluster1 (- Z 1))) 27.95)**
- **(rule (Cluster1 Z) (Q1 (Cluster0 (- Z 1))) 18.01)**
- **(rule (Cluster2 Z) (Q2 (Cluster2 (- Z 1))) 50.75)**
- **(rule (Cluster2 Z) (Q2 (Cluster0 (- Z 1))) 25.53)**
- **(rule (Cluster2 Z) (Q2 (Cluster1 (- Z 1))) 23.72)**

Generated Solo Example



Assessment Experiment

Using our methodology, we inferred grammars from Clifford Brown, Freddie Hubbard, Miles Davis.

Generated solos from each grammar on a different song

Asked users to identify which solo belongs to which artist, how closely they resembled the style of the original

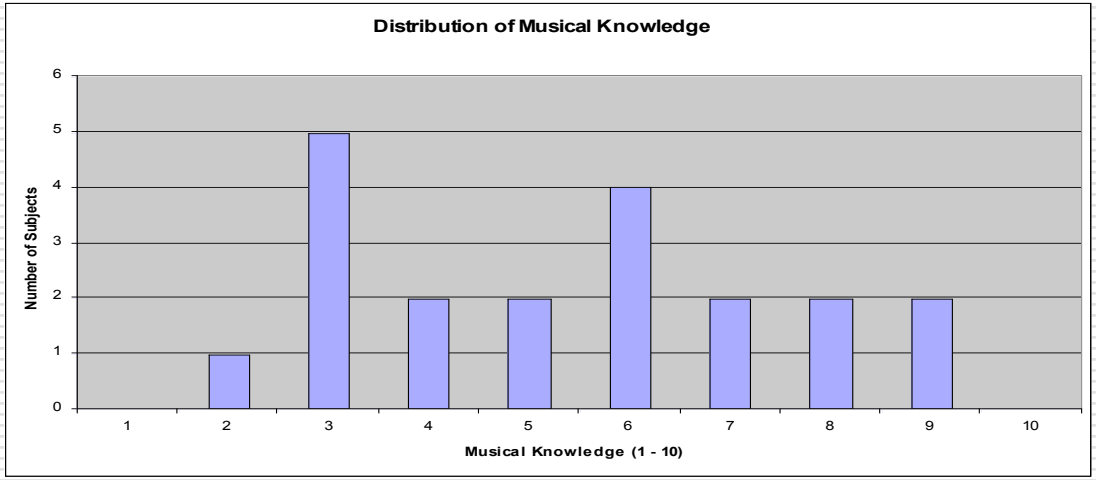
Used same midi instruments, same song that was generated on, and hidden artist names as control elements

Results

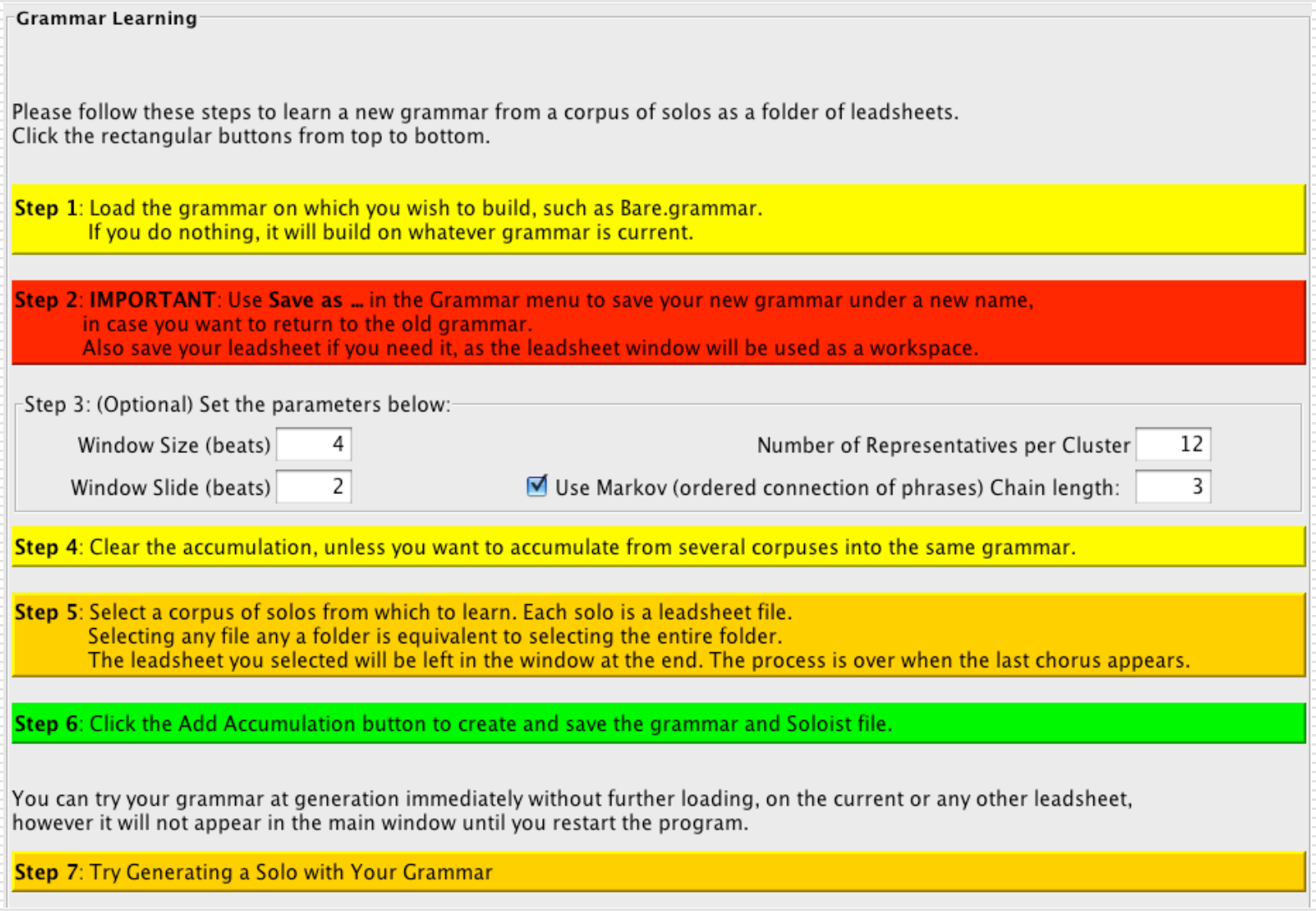
85% correct for matching all three generated solos to artists

Almost all subjects selected either “somewhat close” or “quite close” for resemblance between solo and original

Good diversity in musical knowledge of subject sample space



Impro-Visor v.4 Grammar Learning Tool



Conclusions

- Devised a method of grammatical inference for jazz solo generation
- Key Ideas
  - Abstract musical representation
  - Extraction windows
  - Clustering/Markov Models
- Successful implementation of grammatical inference and solo generation for a variety of artists

For Further Information

- www.impro-visor.com
  (don't forget the hyphen)
- or Google impro-visor
- launch.groups.yahoo.com/group/impro-visor/
  to download our software (free!)